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IMPORTANT PECAN INSECTS AND THEIR CONTROL

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THE PECAN has a number of important insect enemies of more or less extended distribution. Some of these injure the nuts, others the foliage and shoots, and still others the trunk and branches. Owing to the wide diversity in their methods of attack, no general directions for the control of these pests can be given, and in the adoption of remedial measures the peculiar habits of each species must be considered. This bulletin describes the more important insects that injure pecan and suggests the methods that should be followed to avert damage.

IMPORTANT PECAN INSECTS AND THEIR CONTROL.

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THE pecan industry in the South has developed rapidly. This development, however, has been accompanied by an important increase in the number and destructiveness of the insects attacking the crop. The loss to pecan growers from insect attacks has amounted to hundreds of thousands of dollars annually, and in the absence of preventive measures it is certain to increase. The present bulletin gives results of studies of the more important pecan insects by the Bureau of Entomology.

INSECTS INJURING THE NUTS.

THE PECAN NUT CASE-BEARER.[1]

The pecan nut case-bearer, in its larval or "worm" stage, attacks for the most part the immature nuts and is capable of reducing the crop greatly. During May, shortly after the nuts have set and when they are not much larger than garden peas, the larvæ will be found boring into them, and at the point of attack casting out pellets of frass, or borings, which are held together by means of fine silken threads that form a short silk-lined tube. Nuts injured by this insect always show the characteristic mass of frass protruding from the place where the larvæ gained entrance, which is invariably near the junction of the base of the nut with the stem. During the early part of the season, when the nuts are small, one larva will often destroy several nuts before attaining its full growth.

This nut case-bearer, as well as another species[2] that attacks the pecan in a somewhat similar way, has often been reported as destroying from one-third to three-fourths of the total crop of wild pecans

[1] *Acrobasis hebescella* Hulst. [2] *Acrobasis caryivorella* Rag.

FIG. 1.—The pecan nut case-bearer (*Acrobasis hebescella*): Moth. Much enlarged.

in various localities in Texas. Until very recently this insect has not been reported in the cultivated orchards east of Texas, but within the last few years it has become a serious pest in some localities in Florida, Georgia, Alabama, Mississippi, and Louisiana. It would seem that this species is extending its range of destructiveness, and in view of the large acreage of pecan orchards now bearing or coming into bearing, sooner or later it probably will prove a most formidable pest throughout the greater part of the pecan belt.

DESCRIPTION.

In the course of development the pecan nut case-bearer passes through four distinct stages, namely, the egg, the larva or "worm," the pupa or resting stage, and the adult or moth. The grayish-black moth (fig. 1) has a wing spread of about three-fourths of an inch. The head and thorax are brownish and the abdomen is yellowish gray. The forewings are grayish black and each has a ridge or tuft of long black scales extending across it near the basal end. The hindwings are much brighter than the forewings and without any conspicuous markings.

The egg is irregularly oval in outline. When first laid it is white, with a greenish tinge, but as incubation proceeds it becomes pinkish or reddish. It is iridescent in some lights.

The full-grown larva, or caterpillar (fig. 2, at right), is about one-half inch in length, and the general color of the body is dirty olive green. The skin of the body is wrinkled into folds and is sparsely covered with inconspicuous hairs. The head and mouth parts are dark brown, and the cervical shield, or neck, is pale brown, bisected by an inconspicuous whitish-yellow area.

FIG. 2.—The pecan nut case-bearer: Pupa at left, larva at right. Much enlarged.

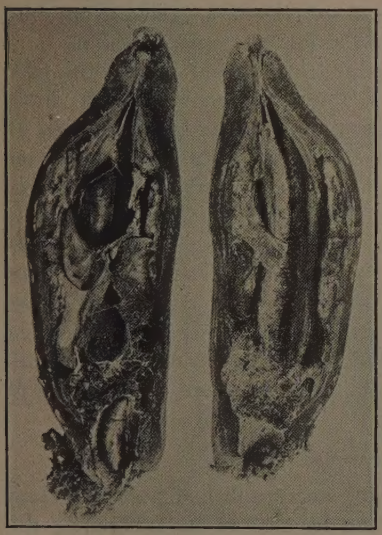

FIG. 3.—The pecan nut case-bearer: Place of pupation in pecan nut.

The pupa (fig. 2, at left) is brown and of the usual form. It is rounded at the posterior end, and here it bears a cluster of small hooked spines. Pupation always takes place in the infested nut or shoot (fig. 3), and upon emergence of the moth the pupal skin is not left protruding as it is in the case of certain other insects.

SEASONAL HISTORY AND HABITS.

This insect has three distinct generations during the year. The larvæ which have lived through the winter become active at the time when the foliage appears in the spring and they attack the young and tender shoots, in which they tunnel by eating out the interior, leaving the outside intact (fig. 4). The moths of the first generation, which are the progeny of the moths developing from the hibernating larvæ, make their appearance from May 7 to 24 and soon after emergence lay their eggs. The eggs are invariably deposited on the calyx end of the nut, and usually at or near the base of the calyx lobes. From 5 to 7 days are required for the eggs to hatch. The larva, as soon as it gnaws its way out of the eggshell, crawls to the base of the young nuts, where it commences feeding. It bores its way into the nuts (fig. 5) and as it feeds it webs together, by means of silken threads, particles of frass and excrement which assume somewhat the shape of a tube smoothly lined with grayish white silk. These tubelike masses of frass are readily seen extruding from the base of infested nuts (figs 5 and 6). The larva period lasts from 22 to 29 days and the pupa period from 9 to 13 days.

Most moths of the second generation emerge from the middle of June up to the first week of July. It was determined that all moths in a large series under observation actually emerged during the period from June 11 to July 15, but the maximum emergence occurred during the last week in June. Second-brood larvæ attack the

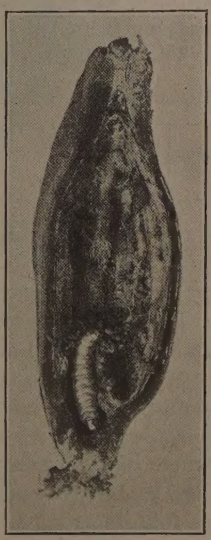

FIG. 4.—The pecan nut case-bearer: Young pecan nut infested by larva.

nuts in the same manner as those of the first generation, but usually the injury to the nut crop by these larvæ is not so great.

Most of the moths of the third generation appear during the first three weeks in August. The larvæ from this generation do little or no damage to the nuts, which usually are beginning to harden at this time, and they seem to prefer to feed in the petioles or tender shoots. The winter is passed as immature larvæ in cocoons or hibernacula, which are formed around the buds. In rearing cages it was observed that larvæ which hatched from eggs laid by third-brood moths usually fed very little before constructing winter cases around the buds. It was noticed, however, that a very few larvæ fed extensively and transformed to pupæ, from which moths emerged during the last part of September, thus indicating a fourth generation. But observations in pecan orchards failed to show any indications of a fourth generation.

CONTROL MEASURES.

The pecan nut case-bearer is already an established pest in certain important pecan-growing sections, and because of its increasing destructiveness certain experiments have been conducted for the determination of positive means of control. During the seasons of 1915 and 1916 series of spraying experiments were conducted in a pecan orchard at Monticello, Fla. All sprayed plats were treated with 1 pound of powdered arsenate of lead plus 3 pounds of slaked stone lime to each 50 gallons of water. In all cases the material was applied with a well-equipped gasoline-power outfit, and a pressure varying from 150 to 200 pounds was maintained.

The results of spraying experiments for 1915 are shown in Table 1.

TABLE 1.—*Spraying experiments against the pecan nut case-bearer, Monticello, Fla., 1915.*

Plat No.	Number of count trees.	Date of spraying.	Total nuts for season.	Number of nuts infested.	Number of sound nuts.	Per cent of sound nuts.
I	5	May 15 and 27 and June 24	3,559	748	2,811	78.98
II	5	May 15 and June 24	3,915	756	3,159	80.68
III	5	May 27 and June 25	4,366	1,125	3,241	74.23
IV	5	Check, unsprayed	1,923	779	1,144	59.49

It will be seen that Plat I, which received three applications, gave 78.98 per cent of sound nuts, and showed a benefit of 19.49 per cent over the check or unsprayed plat, which had only 59.49 per cent of sound nuts. Plat II, which received only two applications, yielded a somewhat greater percentage of sound nuts, while Plat III, which had only one application, yielded 74.23 per cent of sound nuts. The benefit for each plat over the check plat is shown in percentages as follows: Plat I, 19.49; Plat II, 21.19; and Plat III, 14.74. It is worthy of mention that out of the 40.51 per cent of infested nuts on

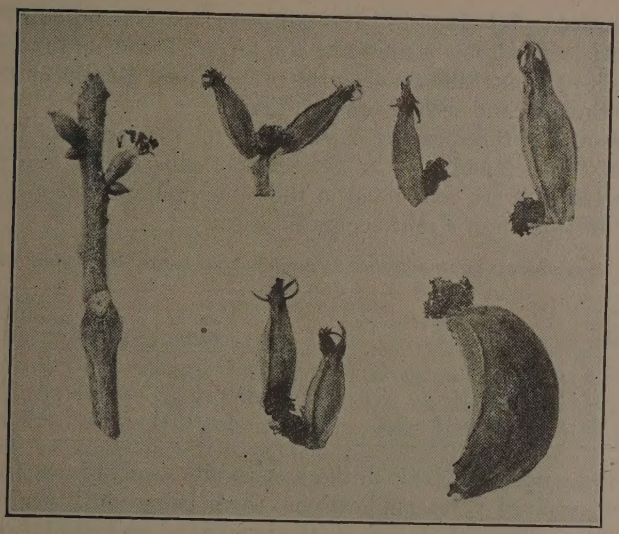

FIG. 5.—The pecan nut case-bearer: Young pecans showing injury by larva.

FIG. 6.—The pecan nut case-bearer: Cluster of infested young pecan nuts.

the unsprayed plat (Plat IV) the injury by the first brood of larvæ amounted to 29.90 per cent, while the second-brood infestation was only 10.61 per cent, thus showing the proportional attacks on the nut crop by the first and second broods of larvæ.

The results of the spraying experiments for the season of 1916 are shown in Tables 2 and 3. The two series of experiments, as outlined in these tables, were conducted in the same orchard, but a distance of fully one-fourth of a mile separated them.

TABLE 2.—*Spraying experiments against the pecan nut case-bearer, Monticello, Fla., 1916.*

Plat No.	Number of count trees.	Date of spraying.	Total nuts for season.	Number of nuts infested.	Number of sound nuts.	Per cent of sound nuts.
I	5	May 12 and 24 and June 24	3,929	190	3,739	95.16
II	5	May 12 and 24	4,608	302	4,306	93.44
III	5	May 12 and June 20	5,522	407	5,115	92.62
IV	5	Check, unsprayed	3,352	581	2,771	82.67

As will be noted in Table 2, the best results were obtained on Plat I, which received three applications, there being 95.16 per cent of sound nuts. The infestation in the unsprayed plat (IV), however, was not severe, since 82.66 per cent of the nut crop came through in sound condition. The actual percentage of infestation in this plat was 17.33 of the total crop, 12.14 being due to the first-brood larvæ. Plats II and III showed 93.44 and 92.62 per cent of sound nuts, respectively. The benefit to each sprayed plat over the check (Plat IV) is given in percentages as follows: Plat I, 12.49; Plat II, 10.77; and Plat III, 9.95.

TABLE 3.—*Spraying experiments against the pecan nut case-bearer, Monticello, Fla., 1916.*

Plat No.	Number of count trees.	Date of spraying.	Total nuts for season.	Number of nuts infested.	Number of sound nuts.	Per cent of sound nuts.
V	5	May 12	2,461	546	1,915	77.81
VI	5	Check, unsprayed	1,569	380	1,189	75.78
VII	2	May 24	474	77	397	83.75
VIII	2	May 12 and 24	690	70	620	89.85

As will be noted in Table 3, Plat V, which received one application on May 12, gave only 77.81 per cent of sound nuts, as compared with 75.78 per cent of sound nuts on the unsprayed plat (VI), showing a benefit of only 2.03 per cent from the treatment. Plat VII, which received one application on May 24, showed 83.75 per cent of sound nuts, while Plat VIII showed a percentage of 89.85 of sound nuts. The benefit to each sprayed plat over the check (Plat VI) is shown in the following percentages: Plat V, 2.03; Plat VII, 7.97; and Plat VIII, 14.07.

In working out control measures for this pest, it has been determined that the spray applications must be made during very limited periods in order that satisfactory results may be obtained. In spraying for this species timeliness and thoroughness of application are

two essentials that must be observed most faithfully, for even the slightest delay or carelessness in applying the spray is likely to result in very disappointing returns from the treatment. Since the eggs of the first brood of moths are hatching for a period of fully two weeks, and as the nuts are growing very rapidly at this time, it is necessary to make two applications for the protection of nuts against infestation by the first-brood larvæ, which, as has been stated before, invariably cause the most damage to the crop. It has been found necessary to spray once for the second-brood larvæ, which usually begin to bore into the nuts shortly after the middle of June.

RECOMMENDATIONS.

Investigations conducted so far show that the best method of control against the pecan nut case-bearer is spraying with arsenate of lead. The arsenate of lead should be used at the rate of 1 pound of the powdered form or 2 pounds of the paste form to each 50 gallons of water, to which should be added the milk of lime from 3 pounds of slaked lime. Three applications will be required and should be made at the following periods:

First.—Shortly after the nuts have set, at which time they are about the size of garden peas.

Second.—One week or ten days after the first application.

Third.—Four or five weeks after the second application.

The date for the first application at Monticello, Fla., during the season of 1916, was found to be May 12. It should be borne in mind, however, that the time of spraying probably will vary somewhat according to latitude and for different seasons.

THE PECAN SHUCKWORM.[1]

A rather slender, white larva or caterpillar (fig. 7, at right), about three-eighths of an inch in length, is found mining the shucks of pecan and hickory during the autumn months. This caterpillar is referred to commonly as the pecan or hickory shuckworm, or huskworm, and for the discussion of the insect in this bulletin the name pecan shuckworm is employed. The mining or tunneling of the shucks often results in the improper development of the nut kernels and

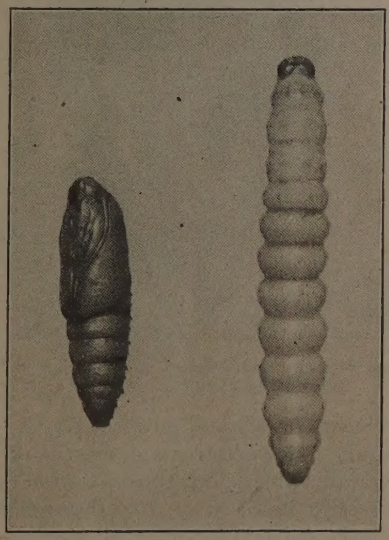

FIG. 7.—The pecan shuckworm (*Laspeyresia caryana*): Pupa at left, larva at right. Enlarged.

[1] *Laspeyresia caryana* Fitch.

prevents the natural separation of the shucks from the nutshells. Nuts attacked by the shuckworm during the late fall usually will mature in fairly good condition for the market, but if the injury takes place early it will result in inferior or unmarketable fruit. Sooty trails on the shell of the nuts often result from the attack of the larvæ, the nuts sometimes being so discolored as to lessen their market value. The damage is not restricted entirely to the matured nuts, for during the summer the early generations of larvæ attack the small, green nuts by eating out the interior, causing them to fall to the ground. (Fig. 8.) Injury of this type is not so noticeable or so widespread as that which takes place in the fall, but it plays no small part in the reduction of the nut crop.

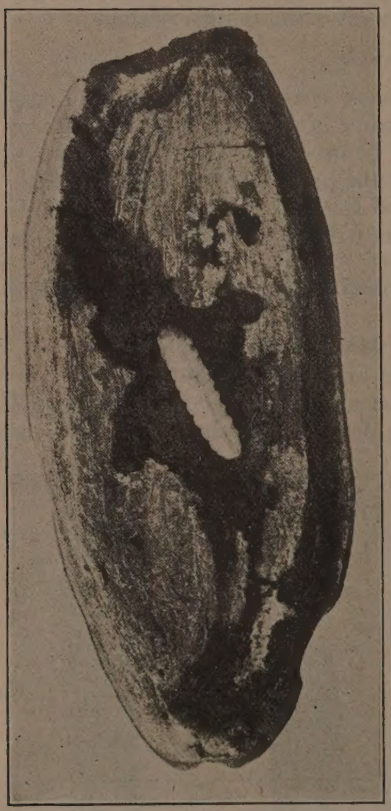

FIG. 8.—The pecan shuckworm: Larva in shuck of nearly matured pecan nut. Enlarged.

Besides attacking the pecan, this insect feeds upon the nuts of the various species of hickory, where the injury it does is precisely like that done to the pecan, except that the destruction of the small, green nuts seems to be greater. Occasionally the larvæ will be found subsisting on the galls formed by a certain species of aphid.[1]

Before nuts have set on pecan trees larvæ sometimes will be found boring into and tunneling the succulent shoots, but this form of injury is very uncommon, as this species is primarily a nut-infesting insect.

DESCRIPTION.

This insect passes through four stages: The egg, the larva, the pupa, and the adult or moth. The moth of the shuckworm (fig. 9) is smoky black, mixed with iridescent bluish and purplish tinges, and the forewings have a series of short, yellowish streaks across their front margins. The moths are rather variable in size, but the maximum expanse of wings is rarely more than three-fifths of an inch. Because of their protective coloration the moths are seldom observed in pecan orchards, even by keen observers.

The egg is small, whitish, and more or less oval, and under high magnification its surface is seen to be wrinkled. The eggs are de-

[1] *Phyllozera caryaecaulis* Fitch.

posited singly on either the nuts or the foliage. During the summer months the average time of hatching is about 5 days, but the time may vary considerably, depending upon the weather conditions.

FIG. 9.—The pecan shuckworm: Moth. Enlarged.

The larva upon hatching is a very small, whitish, 16-footed caterpillar, but when full grown it is about three-eighths of an inch in length and has a creamy white body and light brown head (fig. 7, at right). It is in the larval stage that injury is done to the nuts.

The pupa (fig. 7, at left), which is brownish, is always found within the infested nut. Before transformation to the pupa stage the larva prepares a small silk-lined cocoon, and cuts a small circular hole on the outside of the shuck, which facilitates the issuing of the moth. Upon the emergence of the moth the pupal skin is extended a short distance through the circular cut (see fig. 10), the lid of which remains attached to the nut in a sort of trap-door arrangement.

SEASONAL HISTORY AND HABITS.

The number of broods of the pecan shuckworm probably will be found to vary from one to three for the country as a whole. In the extreme southern portion of its destructive range apparently

FIG. 10.—The pecan shuckworm: Pupal skins protruding from shucks of pecan nuts.

three generations occur each year, but in the Northern States, where the insect subsists on the various species of hickory, there is perhaps only one generation. The moths, which develop from larvæ that spend the winter in the fallen pecan or hickory shucks, begin to appear in northern Florida as early as the middle of February and continue to emerge until the latter part of April, the spring emer-

gence thus covering a period of more than two months. It has been determined, however, that the maximum emergence of moths occurs during the last two weeks of March. Extensive observations have shown that the vast majority of moths come forth before the appearance of the pecan foliage and nuts, and this apparently accounts for the extremely small numbers of first-brood larvæ that attack the pecan trees. The development of the foliage and nuts of the pignut [1] and white hickory [2] is much earlier in the spring than that of the pecan, and it seems that the emergence of moths is timed for these host plants. In this connection it is interesting to note that considerable damage always is done to the very small hickory nuts by the first brood of larvæ, while the very small pecan nuts seem to escape such injury. Some first-brood larvæ will be found attacking the tender shoots of pecan, but the apparent reason for the immunity from attack of the recently set pecan nuts is the fact that the emergence of moths does not coincide very well with the development of the nut. Since the moths are capable of flying some distance, it is likely that for the purpose of egg-laying some of those emerging from pecan shucks during the spring succeed in reaching hickory trees growing adjacent to pecan orchards.

The moths deposit their eggs on the young nuts or foliage, and during the summer months the period of incubation lasts about 5 days. Upon hatching the larvæ gnaw their way into the nuts by making a pinhole entrance, and proceed to mine the shucks in the nearly matured fruit, but some larvæ bore into the interior of the green nuts and cause them to drop to the ground.

During the spring and summer the larvæ usually feed from 3 to 4 weeks, and transform to pupæ within the green nuts or the shucks of the matured fruits. The length of the pupa stage is found to range from 9 to 45 days. During the summer months it lasts about 11 days, while most of the pupæ from overwintering larvæ transform to moths in 18 days, although some few moths do not issue for a considerably longer period. The pupation of the overwintering larvæ occurs from about the first of February until the middle of April.

As stated before, the larvæ of the first brood feed for the most part on the small hickory nuts, but during the last days of June and through July and August, although continuing their depredations on the hickories, the larvæ will be found attacking the green pecan nuts. The first and second broods of larvæ destroy the interior of the nuts and invariably cause them to drop. The last brood of larvæ, which attacks the nearly matured nuts with hard shells (fig. 11), feeds only on the shucks, in which they mine and attain full growth before the advent of cold weather. They pass the winter as larvæ in the shucks on the ground or in shucks that remain on the trees.

[1] *Hicoria glabra* Britt. [2] *Hicoria alba* Britt.

CONTROL MEASURES.

It is impracticable to spray for the control of this pest, because of the great difficulty encountered in destroying the larvæ before they enter the nuts or shucks. It will be found impossible also to destroy the larvæ and pupæ, or prevent the emergence of moths, by plowing under the shucks during the fall or winter months, as experiments have shown that the burial of infested shucks as deep as 6 inches during the late fall did not prevent many moths from emerging the following spring.

Since the insect passes the winter as larvæ in the shucks on the ground, it seems that the best method of control is to gather and destroy all shucks, and this should be done immediately after the harvesting of the nut crop, or not later than the middle of February. By the adoption of this method the majority of the larvæ will be killed and thus the infestation of the pecan orchard during the ensuing season will be prevented.

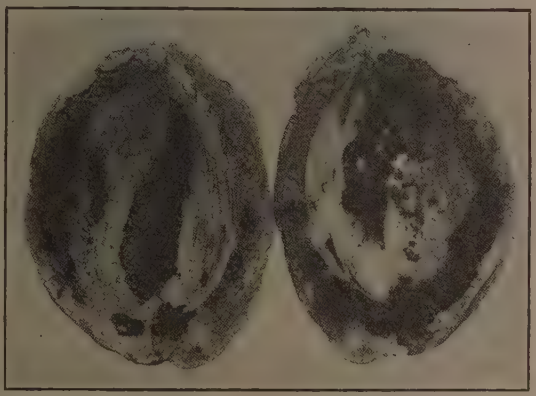

FIG. 11.—The pecan shuckworm: Larval injury to matured pecan nuts.

Hickory trees growing adjacent to pecan orchards will prove always a source of infestation by this pest as well as other injurious insects. It would seem, therefore, that the cutting down of hickory trees in the immediate vicinity of the orchards would be a very good procedure for pecan growers.

THE PECAN WEEVIL.[1]

The pecan weevil, often termed the hickory-nut weevil, has long been known in some sections as a serious drawback to the successful culture of pecan nuts as well as hickory nuts. The greatest damage reported has been on the wild pecans in Texas, but this insect is also a formidable pest in certain restricted localities in Georgia, Mississippi, and Louisiana, where the so-called paper-shell pecans are grown on a large scale. The injury by this weevil is recognized readily by the circular holes in the nutshells (fig. 12), which are made by the grubs in leaving the nuts to enter the ground for hibernation and subsequent pupation. One grower in middle Georgia reported that 90 per cent of his Stuart pecans and 15 per

[1] *Balaninus caryae* Horn.

cent of the Schley variety were injured by this insect, but the orchard in question was adjacent to a 250-acre woodland containing many native hickory trees the nuts of which were infested severely. No

FIG. 12.—The pecan weevil (*Balaninus caryae*): Exit holes of larvæ in pecan nuts.

doubt the serious infestation of the nut crop in this orchard was in a large measure attributable to the close proximity of hickory trees. Another grower in Georgia reported extensive damage to Rome and Stuart varieties of pecan, and in one locality in Louisiana this weevil is reported to have caused a loss of 65 per cent of the pecan yield.

Although this insect is distributed very widely throughout the country, occurring on both the wild and cultivated pecans as well as native hickory nuts, thousands of acres of pecan orchards have not yet suffered any loss from attack, so far as is known. One grower in Georgia found that out of a crop of 48,000 pounds, so far as he observed, not a single nut was affected by the weevil. Similar reports have been received from large pecan growers in

FIG. 13.—The pecan weevil: Adult male at left, adult female at right. Enlarged.

Florida, Mississippi, Louisiana, and Texas. The development of this insect shows four stages: (1) The egg, (2) the larva or grub, (3) the pupa, and (4) the adult or weevil. The parent of the grubs which destroy the interior of the nuts is a small, long-snouted beetle (fig. 13) closely related to the chestnut weevil. The beak, or snout, of the female is much longer than that of the male. The general color of the beetles is dull, dark brown, with a slight tinge of gray.

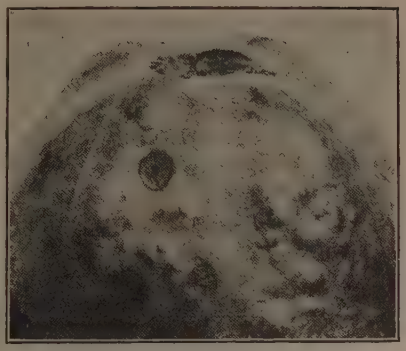

FIG. 14.—The pecan weevil: Egg puncture in the pecan shuck. Enlarged.

The eggs are small, somewhat elongated, irregularly shaped, and translucent white. With her long, slender, but strong beak the female beetle makes a small hole or gallery through the shuck and shell (fig. 14) and with her ovipositor inserts the eggs into the kernel of the nut.

The larva is a robust, yellowish white grub, with a red or light reddish brown head. It is by this stage of the insect that the kernels of the nuts are destroyed (fig. 15). When the larvæ reach maturity they leave the nuts by gnawing circular holes in the shells, and immediately enter the soil to a depth of about 6 to 8 inches and there pass the winter.

FIG. 15.—The pecan weevil: Grubs, or larvæ, within pecan nuts.

The pupa is of the usual form and is somewhat lighter in color than the larva. It is formed within the soil, in a small earthen cell made by the larva at the time of entering the ground.

SEASONAL HISTORY.

In the South the beetles emerge from the ground and appear on the pecan trees during August and September. Shortly after emer-

gence they are to be found laying eggs in nuts that are approaching maturity. Adults may be found in the ground as late as November, as one specimen, apparently fully developed, was taken on November 23, 1915, about 8 inches below the surface of the soil. The main egg deposition takes place during the first half of September, but apparently eggs are laid over a much longer period, as is evidenced by the time during which larvæ leave the nuts. It has been found that the egg stage lasts about 9 days, and as many as 7 eggs may be deposited in a single nut, although the usual number, perhaps, is 3. According to the writer's records, the larvæ are gnawing their way out of the nuts from September 28 to November 25, although certain observers have reported that the larvæ may leave the nuts as late as January. Immediately upon leaving the nuts they enter the soil to a depth of 6 inches or more for the purpose of hibernation.

CONTROL MEASURES.

The fumigation of chestnuts with disulphid of carbon has been used for a long time as a remedy against the chestnut weevil, and no doubt this treatment will prove effective against the pecan weevil. The nuts to be fumigated should be placed in a tight box or barrel or other receptacle provided with a tight-fitting lid. The disulphid of carbon should be used at the rate of 1 ounce to each bushel of nuts, and fumigation should last for from 24 to 48 hours. The chemical should be placed in a shallow dish or pan on the top of nuts, and immediately after the liquid is poured into the dish the lid should be put in place, care being taken to have it fit tightly. After the nuts have been exposed to the fumes of this gas for from 1 to 2 days, all larvæ will have been killed and the lid should be removed to expose the nuts to the air. Since the vapor of disulphid of carbon is very inflammable when mixed with air, fire should be kept away from it.

The extensive cultivation of the soil in pecan orchards should result in the destructuon of many of the larvæ and pupæ by their exposure to the air and to natural enemies, and where the weevil is prevalent this practice is recommended. After the harvesting of the crop in the fall, hogs should be pastured in the orchard, as they will find the nuts that have been overlooked, and by their rooting into the soil should destroy many of the hibernating larvæ.

INSECTS INJURING THE FOLIAGE AND SHOOTS.

THE PECAN LEAF CASE-BEARER.[1]

The pecan leaf case-bearer is one of the worst pests affecting the culture of pecans, and it occurs in very injurious numbers in orchards in the southern portion of the pecan-growing area, extending from Florida to Texas. Although this insect has been reported definitely

[1] *Acrobasis nebulella* Riley.

from practically all the Southern States in which pecans are grown, it probably ranks as a serious pest only in Florida and the southern parts of Georgia, Alabama, Mississippi, Louisiana, and Texas. The insect occurs also in some of the Northern and Middle Western States where the pecan is not grown, and here it subsists on the various hickories. Generally speaking, the pecan leaf case-bearer is distributed over approximately the same territory as are its preferred hosts, namely, the pecan and hickories. Evidently certain climatic fac-

FIG. 16.—The pecan leaf case-bearer (*Acrobasis nebulella*): Injury to young pecan buds in spring by larvæ.

tors limit the destructiveness of this species, and because of these conditions it has not been able, apparently, to become a pest in the northern part of the pecan-growing sections.

The most serious damage by the leaf case-bearer is done during the early spring and is inflicted by the "worms," which emerge from their winter cases and feed voraciously upon the unfolding buds and leaves. (Fig. 16.) These "worms," or larvæ, are small at this time and dark brown, but soon change to dark greenish as they feed upon

the foliage. Upon leaving the winter cases the larvæ enter the buds at the tips and partake of their first meal after having spent several months in hibernation. On badly infested trees the buds and tender leaves suffer serious injury (fig. 17), and often the foliage is consumed by the larvæ as fast as it puts forth. It is not unusual to see pecan trees kept in a defoliated condition for weeks during the spring on account of the attacks of this insect. (See fig. 18.) Since the larvæ are not at all discriminating in their feeding habits, devouring the blossom buds as well as the leaf buds, they are capable of reducing greatly the yield of nuts for the current season, besides leaving the trees in a more or less weakened condition.

FIG. 17.—The pecan leaf case-bearer: Injury to pecan foliage and flowers.

DESCRIPTION.

As is the case with all moths, the pecan leaf case-bearer has four distinct stages, namely, the egg, the larva, the pupa, and the adult, or moth. The moth (fig. 19) measures about two-thirds of an inch across the expanded wings and presents a wide variation in color. The head, thorax, and base of forewings and legs are snow-white in the males, but in the females these parts are dusky gray. The abdomen is whitish marked with brown. The outer two-thirds of the forewings is gray, with blackish blotches or spots, which are somewhat variable, and not far from the base of the forewings is a reddish brown stain.

The egg (fig. 22) is oval and white, with a slight greenish tinge.

The larva (fig. 20), which is the form that inflicts the injury to buds and foliage, is a dark green, cylindrical caterpillar, measuring a little over a half-inch in length when fully grown. The head is rounded, shiny dark brown or black. The general color of the body is very dark green, except the prothoracic shield, which is somewhat lighter. The skin of the body is very much wrinkled into folds, and the entire body is sparsely covered with fine long hairs.

The pupa (fig. 21), to which the full-grown larva changes, is of the usual form and without conspicuous markings. When first formed it is fairly dark brown, with a tinge of olive green, but with age it turns to a deep shiny mahogany brown. The pupa is formed within the larval case, and upon the emergence of the moth the pupal skin is not extruded, as is the case with some other moths.

FIG. 18.—The pecan leaf case-bearer: Pecan tree defoliated.

SEASONAL HISTORY AND HABITS.

Only one generation of the pecan leaf case-bearer develops during the course of a year, but more or less variation exists in the development of the different stages, as will be shown presently. For instance, from material under observation during the season 1913 it was determined that the moths, numbering in all 269, emerged between May 9 and July 12, inclusive. During 1914 the dates of issuance for 385 moths varied from May 15 to August 5, and during 1915 the dates at which the 591 moths emerged varied from May 22 to July 23. For the three years the time of greatest, or maximum, emergence was the same, being the latter half of June.

FIG. 19.—The pecan leaf case-bearer: Moth, or parent insect. Enlarged.

Because of the wide variation in moth emergence a corresponding variation occurs also in the time of egg laying. Eggs are deposited always on the underside of the leaves and usually near the junction of the vein with the midrib. (Fig. 22.) The egg stage has been found to last from 6 to 9 days, the average being 7.14 days.

The eggs hatch from about the middle of May until the latter part of July or the first few days in August, depending more or less upon the weather conditions. When the young larvæ gnaw their way out of the eggshells they commence feeding upon the portion of the leaflets immediately adjacent to the place where egg laying or oviposition occurred. (Fig. 23.)

FIG. 20.—The pecan leaf case-bearer: Larva and case. Enlarged.

Throughout the summer and during the early fall the larvæ feed very sparingly upon the foliage, and as they extend their feeding quarters they enlarge their little winding cases (fig. 23), which afford very good protection for them. Although they may feed for nearly three months, or even longer in some instances, they rarely attain a length greater than six one-hundredths of an inch in the fall. During the latter part of September they begin to seek winter quarters around the buds, and here they construct small, compactly woven, oval cases known as hibernacula (fig. 24), and by the middle of October practically all larvæ have left the foliage and are to be found snugly protected in these cases. Shortly before the foliage begins to drop in the autumn the little larvæ abandon the leaves upon which they have been feeding and attach their winter cases securely to the buds and twigs. They remain in hibernation until the latter part of March or the first part of April, at which time the buds on pecan trees usually begin to open.

FIG. 21.—The pecan leaf case-bearer: Pupa. Enlarged.

Just as the buds are opening, the larvæ emerge from their winter cases and attack the unfolding leaves. Their pernicious feeding habits at this time result in serious injury to the foliage and in reducing greatly the yield of nuts. The larvæ feed very voraciously during the spring and some of them reach full growth as early as the last days in April, but the majority do not attain full growth until May or early in June. The larvæ always transform to pupæ within their cases (fig. 25), and just before pupation takes place they spin a flimsy layer of silk over the free end of their cases. The pupa period has been found to cover from 16 to 23 days, the average being a trifle over 17 days. The first adults make their appearance about

the middle of May and moths continue to come forth until the first week in August. Thus the life cycle of this insect, which it will be seen covers the entire year, is completed.

CONTROL MEASURES.

Although the pecan leaf case-bearer is attacked by a number of parasitic insects, it has been found that the parasites or other natural enemies [1] can not be relied upon to control this pest, but artificial measures of control can be instituted successfully and practically to check its ravages.

FIG. 22.—The pecan leaf case-bearer: Eggs along midrib on lower surface of pecan leaf. Enlarged.

FIG. 23.—The pecan leaf case-bearer: Injury by newly hatched larvæ on lower surface of pecan leaf. Enlarged.

Investigations conducted during the last three years show conclusively that the pecan leaf case-bearer can be controlled by spraying with arsenate of lead during the late summer. The arsenate of lead should be used at the rate of 1 pound of the powdered or 2 pounds of the paste form to each 50 gallons of water, to which should be added 3 pounds of slaked stone lime. Under no circum-

[1] The following parasites have been reared from this species: *Itoplectis conquisitor* Say, *Triclistus apicalis* Cress., *Calliephialtes grapholithae* (Cress.), *Pristomerus* sp., *Macrocentrus* sp., *Meteorus* sp., *Habrobracon variabilis* Cush., *Orgilus* sp., *Secodella acrobasis* Cwfd., *Spilochalcis vittata* (Fab.), *Cerambycobius* sp., *Trichogramma minutum* Riley, *Exorista* sp., and *Leskiomima tenera* Wied. Three species of birds, namely, the blue jay, the mockingbird, and the orchard oriole, have been observed feeding upon the larvæ.

FIG. 24.—The pecan leaf case-bearer: Winter cases, or hibernacula, around pecan bud. Enlarged.

FIG. 25.—The pecan leaf case-bearer: Larvæ in their cases and injury to pecan leaflets.

stances should the arsenate of lead be used without the addition of lime, as more or less serious injury to the foliage or nuts is likely to result. Spraying may be done with the same degree of effectiveness from the first part of August up to the middle of September. Care should be taken not to delay the spraying too long in the fall, as observations have shown that some larvæ seek hibernation quarters toward the latter part of September, although the vast majority of them do not construct winter cases until the first week in October. It should be borne in mind also that only the larvæ that have fed on poisoned foliage will be killed. Remembering these points, growers should realize the importance of spraying at the proper time and apply the poison thoroughly to all parts of the foliage, especially the under side, upon which the larvæ are feeding. Only one thorough application is necessary to control this pest in pecan orchards, even though the infestation is most severe. It is unnecessary to spray more than once for this pest providing the spray is applied thoroughly at the proper time.

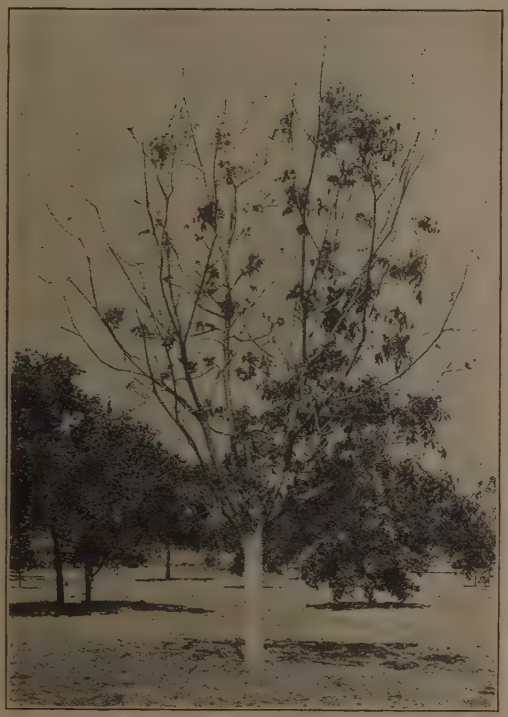

FIG. 26.—The pecan cigar case-bearer (*Coleophora caryaefoliella*): Pecan tree largely defoliated by this insect.

THE PECAN CIGAR CASE-BEARER.[1]

The pecan cigar case-bearer usually is to be considered as a pest of only minor importance, but reports are received of its occurrence in injurious numbers in pecan orchards during the spring months and of the infliction of serious damage to the buds and foliage. (Fig. 26.) This insect does not confine its attacks to the pecan, as it feeds upon the various species of hickory and the black walnut. The pecan cigar case-bearer is distributed over a wide range of the country,

[1] *Coleophora caryaefoliella* Clem.

FIG. 27.—The pecan cigar case-bearer: Type of injury by larva to pecan leaflets.

extending from Florida to the extreme western border of Texas, and as far north as New Hampshire. When the buds of pecan trees are opening, or just after they have begun to unfold, the hibernating larvæ become active and attack them, continuing their feeding operations on the foliage (fig. 27) until about the middle of May (in Florida), when they become full grown and transform to pupæ within the larval cases (fig. 28, *b*, *c*). The pupa period lasts about two weeks, and during June the moths (fig. 28, *a*) appear in numbers on the pecan. The eggs are deposited on the foliage and they hatch within a few days. Upon hatching, the larvæ feed first as leaf-miners, but later in the season they construct the small cases, in which they feed upon the leaves until a short time before the foliage drops in the fall. The larvæ migrate then to the twigs or larger limbs or trunks, where they attach their cases and spend the winter.

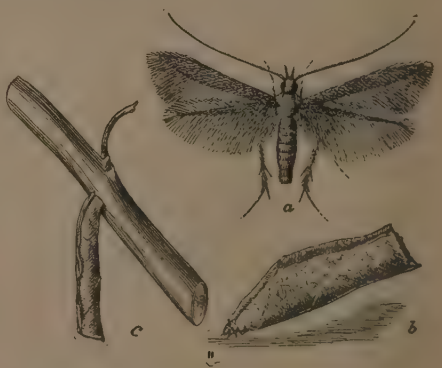

FIG. 28.—The pecan cigar case-bearer: *a*, Moth; *b*, *c*, larvæ in cases. Enlarged. (Russell.)

CONTROL MEASURES.

If this insect occurs in injurious numbers in the spring it can be controlled readily by spraying the trees with arsenate of lead at the rate of 1 pound of the powdered or 2 pounds of the

paste form to each 50 gallons of water, to which should be added 3 pounds of slaked stone lime. This species, however, rarely is abundant enough in orchards to call for special treatment. In pecan orchards in which spraying is directed against the more injurious pests the pecan cigar case-bearer rarely will be a source of trouble, as the larvæ of this and the other species are killed by the same treatments.

THE PECAN BUD-MOTH.[1]

The pecan bud-moth is a pest of greater or less importance in the pecan orchard and nursery. At times it becomes so abundant that the damage caused by the larvæ feeding upon the terminal buds of pecan nursery stock entails considerable loss to nurserymen. This insect evidently occurs throughout the pecan-growing region, as reports of damage have been received from most of the Southern States. Besides feeding upon the pecan, it has been recorded doubtfully from various hickories, and doubtful records exist of its occurence on the black walnut.

DESCRIPTION.

The general color of the moths is gray, mottled with blackish-brown patches and streaks, and the expanse of wings is just a little more than half an inch. The blackish-brown patches on the forewings are arranged in a zigzag fashion from the base of each wing across its middle to the tip. The hindwings are without markings and are dusky gray, with the outer margin somewhat darker. The moths are very active and are often found frequenting the tree trunks, on which they rest head downward. When disturbed the moth will fly away in a jerky manner for a short distance and then suddenly wheel about to return to the tree trunk that it just left.

FIG. 29.—The pecan bud-moth (*Proteopteryx bolliana*): Pupa at left, larva at right. Enlarged.

The eggs (fig. 30) are small, oval, whitish, and iridescent in some lights. When the trees are in foliage the eggs are laid upon the upper surface of the leaves, but before the buds push forth in the spring eggs are often found deposited on the twigs.

When full grown the larva (fig. 29, at right) is about five-eighths of an inch in length. The body, which is sparsely covered with fine hairs, is yellowish green, and through

[1] *Proteopteryx bolliana* Sling.

its semitransparent skin can be seen the brownish contents of the alimentary canal. The head and cervical shield, or neck, are shiny dark brown in color in full-grown larvæ, but on very young larvæ they are jet black.

FIG. 30.—The pecan bud-moth: Eggs on pecan leaflet.

The pupa (fig. 29, at left) is of the usual light-brown color. The size varies somewhat, but the length rarely is more than a third of an inch. The pupæ usually are formed in rolled-up leaves or infested buds, but occasionally they can be found under bark scales or at the crown of the tree.

SEASONAL HISTORY.

The number of generations a year varies somewhat in different sections. In the extreme southern portion of its distribution five or six occur during the course of a season. The pecan bud-mouth passes the winter in the adult stage. As soon as the buds on the pecan trees begin to open, the moths commence to lay eggs, which usually are deposited on the branches near the buds, but after the foliage appears the eggs are laid invariably on the upper surface of the leaves. (Fig. 30.) The eggs hatch in from 3 to 6 days, depending upon the temperature. The larvæ feed from 21 to 29 days, the average being about 25 days. The pupa stage lasts from 8 to 13 days, but the average period is about 10 days. The average life-cycle period is 40 days—5 days being spent in the egg stage, 25 days as larva, and 10 days as pupa.

CONTROL MEASURES.

Ordinarily this bud-moth does not occur in sufficient numbers to be ranked as a serious pest of the pecan. In bearing pecan orchards it is rarely troublesome, but during some seasons it is responsible for considerable damage to the pecan nursery trees. This species is primarily a bud feeder, and in attacking the terminal buds on the young trees it causes a stunted growth as well as excessive branching. This feature is especially objectionable from the nurseryman's point of view, since the pecan nursery stock is sold according to its height. It has been observed that nursery trees growing vigorously usually open and unfold their terminal buds so rapidly that the larvæ

apparently do not have sufficient time to inflict serious damage. It has been observed, further, that the larvæ feed on the foliage (fig. 31) if compelled to do so by the rapid growth of the tree, and under these conditions they will eat the outer parts of the leaves. During dry seasons, especially in the spring of the year, pecan nursery stock grows very slowly and is seriously injured by larvæ of the bud moth. As a nursery practice it is strongly recommended that the trees be kept in a vigorous growing condition by thorough cultivation and fertilization. Spraying with arsenicals during the spring just as the buds are opening will help materially to hold this pest in check, but this treatment is not advised unless the infestation is very serious. Observations would indicate that the pecan bud-moth never does sufficient damage in bearing orchards to warrant special spraying.

FIG. 31.—The pecan bud-moth: Larval injury to pecan foliage.

THE FALL WEBWORM.[1]

Perhaps the commonest insect coming under the observation of pecan growers is the so-called fall webworm, which constructs unsightly nests or webs over the twigs and foliage. These webs are more abundant during the late summer and fall, but since this insect has two generations in the South, the webs are to be found on pecan trees as early as May. Trees defoliated in late summer frequently develop leaves and flowers to the detriment of the crop the following year.

The moths (fig. 32), which usually are pure white but sometimes have black or brown spots on the forewings, emerge in the spring, during April and May. The eggs are deposited in masses on the leaves, are greenish white in color, and hatch in about a week (fig. 32). The larvæ are gregarious, and each colony forms a web in which all the caterpillars feed, eating the upper and lower surfaces of the leaves. When they need additional leaves for food they enlarge the web (fig. 33), which sometimes becomes very large and conspicuous.

[1] *Hyphantria cunea* Drury.

The full-grown larvæ (fig. 34) usually measure an inch in length and are covered with long white and black hairs arising from numerous tubercles. On reaching maturity they leave their webs and transform to brown pupæ in flimsy, hairy cocoons beneath rubbish on the ground, under the scales of bark, or just under the surface of loose soil. The earliest date for the emergence of moths of the second brood is June 26, but most of the moths of this generation do not appear until later. The second-brood larvæ have been found deserting their webs during the latter part of September, all through October, and occasionally as late as the first week in November, for the purpose of pupation. This insect passes the winter as pupæ, and moths appear the following year, during April and May.

FIG. 32.—The fall webworm (*Hyphantria cunea*): Moth and egg mass. Enlarged.

CONTROL MEASURES.

All webs containing caterpillars that can be reached conveniently should be removed and the larvæ destroyed. Sometimes burning the webs on the trees will be found practicable, but it should be done carefully, so that much of the foliage will not be scorched. A long-handled tree pruner can often be used to advantage in removing the webs that are well up in the trees. When the fall webworm is extremely abundant, as is the case in some years, the foregoing measures can be effective to a limited degree only. Pecan orchards sprayed for the pecan leaf case-bearer will suffer no material damage from this insect, as the same treatment will destroy these caterpillars as well as several other leaf feeders.

THE WALNUT CATERPILLAR.[1]

In the South branches of large pecan trees often are defoliated by colonies of a caterpillar which when full grown is black, with long whitish hairs, and nearly 2 inches in length. This is the so-called walnut, or pecan, caterpillar. When young it is brownish, with white stripes and somewhat more hairy than the matured

[1] *Datana integerrima* G. & R.

FIG. 33.—The fall webworm: Web and caterpillars.

FIG. 34.—The fall webworm: Portion of web enlarged, showing larvæ.

larva. The larvæ upon hatching from eggs, which are deposited in masses (fig. 35) on the underside of the leaves, feed at first only on the underside of the leaflets, but later they devour the entire foliage except the stems and petioles. Small pecan trees, especially nursery stock, sometimes are defoliated completely, and it is not uncommon to see large branches on bearing trees stripped of their foliage. The larvæ feed in colonies (fig. 36), and in molting the larger caterpillars invariably leave their feeding place and crawl to the trunk or larger limbs, where in a mass they shed their skins, which may adhere to the bark for several weeks or longer. After molting they ascend the tree to continue their feeding depredations, and when fully grown crawl down the trunk and immediately enter the soil to a depth of a few inches. Here, in a day or two, pupation takes place.

FIG. 35.—The walnut caterpillar (*Datana integerrima*). Egg mass. Enlarged.

In the North this insect has only one generation yearly, but evidently at least two generations occur in the South.

According to Bureau of Entomology records the moths (see fig. 37) developing from overwintering pupæ emerge from April 15 to July 15, and shortly after emergence egg laying takes place on the underside of the leaflets. The eggs, which are laid in masses usually numbering from about 100 to 150 each, hatch in a little less than a week and the larvæ feed for 25 days or longer before completing their growth. The caterpillars enter the soil to transform to brown pupæ, in which state they remain about 18 days for the summer generation. In the case of the fall generation the winter is passed as pupæ (fig. 38) in the ground and the moths do not emerge until the following spring or early summer. The second-brood larvæ enter the soil from the middle of September until the last week in October.

CONTROL MEASURES.

Whenever the egg masses or colonies of the caterpillars are discovered they should be destroyed promptly. Growers often may discover the larger larvæ massed on the tree trunks in the act of

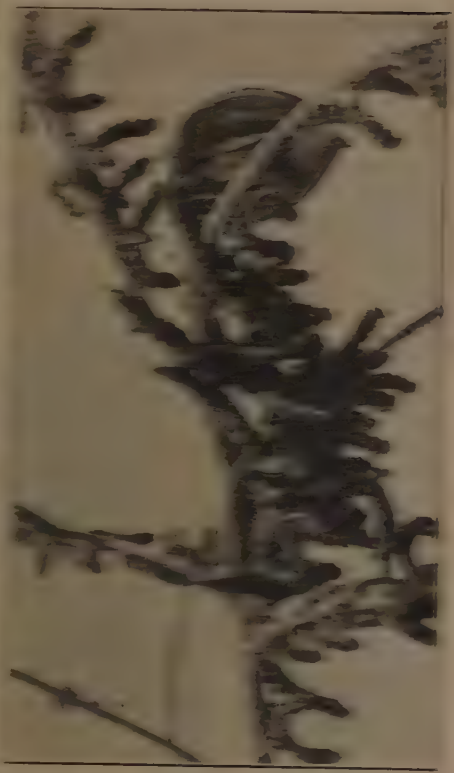

FIG. 6.—The [illegible]

FIG. 7.—[illegible]

THE PECAN PHYLLOXERA.

[illegible] the pecan [illegible] the pecan [illegible] the pecan [

to find seedling nursery stock covered with galls, but budded or grafted pecan trees growing adjacent may, and usually do, escape injury.

Certain pecan trees in orchards are exceptionally subject to attacks by this insect, while trees growing immediately adjacent to the affected ones are not attacked and mature their full crop of nuts. Judging from the past behavior of the hickory phylloxera, it does not appear that this insect will be a very serious drawback to commercial production of improved varieties of the pecan under orchard conditions. This aphid attacks certain species of hickory as well as the pecan.

CONTROL MEASURES.

Under ordinary circumstances pecan trees slightly infested by this insect will hardly demand special remedial measures. Like many other insects, this species is subject to great fluctuation in numbers, and the amount of damage therefore will vary considerably from year to year. This variation in abundance is due to the fact that the insect is held more or less completely in check by natural enemies.

FIG. 38.—The walnut caterpillar: Pupa. Somewhat enlarged.

So far as present knowledge of this insect goes, no very satisfactory method of control can be employed during the growing season on trees that are so badly affected that the nut crop is seriously interfered with. It has been recommended that as many as possible of the badly affected leaves and shoots be clipped off by means of a 12-foot pruner before the galls open, and then burned immediately; but this treatment will hardly prove feasible for large trees. Perhaps the insect could be destroyed while in the egg stage, during the dormant season, by spraying with lime-sulphur solution, kerosene emulsion, or miscible oil; but so far no actual work along this line has been undertaken.

If certain varieties of pecans show an exceptional susceptibility to infestation year after year, top-working such trees with resistant sorts doubtless would prove a practicable means of avoiding injury by this species.

THE LITTLE HICKORY APHID.[1]

Often during the course of the season, especially in the spring and autumn, pecan foliage is seen to be infested by a little lemon-yellow aphid or plant-louse. This insect is commonly called the little hickory aphid, because it was first discovered feeding upon the hickory and because of its small size. Besides feeding upon the hickory

[1] *Monellia caryella* Fitch.

and pecan, it has been reported infesting the California black walnut [1] and hybrids derived from this tree.

About the time the buds on pecan are opening, the eggs of this aphid begin to hatch. Later the mature insects migrate to the unfolding foliage, upon which they feed by sucking the juice from the plant. They continue their feeding operations throughout the growing season, or until the trees shed their leaves. Throughout the spring and summer the nonsexual forms give birth to living young, but in the autumn (September and October) the sexual forms make their appearance on the trees and after mating the females deposit eggs on the twigs. These do not hatch until the following spring.

FIG. 39.—The hickory phylloxera (*Phylloxera* sp.): Galls on pecan.

Fortunately this insect does so little damage to pecan foliage that no special remedial measures are required. Its many natural enemies help much in keeping it in check. A significant feature about the infestation by this aphis is the abundance of "honeydew" excreted upon the foliage. Usually leaves covered by the sticky excretions support the growth of a black fungus which makes the foliage look unsightly and perhaps interferes to some extent with the proper respiratory action of the plant.

INSECTS INJURING THE TRUNK AND BRANCHES.

"WHITE ANTS," OR TERMITES.[2]

Pecan trees, as well as other kinds of plants, occasionally are injured and sometimes killed by attacks of the so-called white

[1] *Juglans californica.*

[2] *Leucotermes flavipes* Kollar is the most widespread and abundant species of termite in the Eastern States.

ants, or termites. Pecan growers in certain sections are familiar with these pests under the name "wood lice," the insects being so named because they often mine large galleries in dead wood and foundation timbers. On account of their underground habits and method of attack, termites usually escape detection until serious damage has been done, and are destroyed with great difficulty. The reports of injury to pecan trees have been confined for the most part to seedlings 1 or 2 years old growing on recently cleared land. Sometimes young budded and grafted pecan trees are injured or killed by termite attacks, but in most if not all cases the orchards were set out on new land containing an abundance of dead wood and humus.

As is the case with true ants, termites live in colonies, and because of their similarity to ants in appearance and habits the name "white ants" has come into more or less common usage. Termites only occasionally attack living trees, their principal and most serious damage being done to foundation timbers and woodwork of buildings. In cut-over woodlands they often are prevalent under the bark of dead logs or beneath the fragments of wood lying on the ground. On small seedling trees from 1 to 2 years old the taproot frequently is hollowed until little more than a shell of bark remains. (Fig. 40.) Termites usually gain entrance to the trees below ground, but their galleries may extend for an inch or so above the soil inside the heartwood. Apparently they attack grafted trees at the point where the graft has not healed over smoothly with the seedling stock.

The affected trees as a rule do not show any indication of injury until they are damaged beyond remedy, and then they die very quickly, as is shown by the sudden wilting of the leaves.

CONTROL MEASURES.

Because of the underground habits of termites it is difficult to apply a direct remedy to affected trees. Since they live in colonies and their nests usually are in the ground somewhere near the affected trees, it is important not only to kill the termites within the trees, but also to locate and destroy the inhabitants of the nests, in order that permanent results may be obtained. Nests perhaps can be destroyed best by pouring carbon disulphid into them and then immediately packing the soil around the nest. This is a volatile liquid, and the gas, being heavier than air, will penetrate all recesses of the nest and cause the destruction of the termites. Since carbon-disulphid treatment is somewhat dangerous to plant life, care should be employed not to use very large dosages around the trees. Sprinkling of tobacco dust in the nests and around the roots of affected trees has been reported to give good results, but the writer never has seen this treatment

in practice, and therefore can not recommend its use with any degree of certainty as to its effectiveness.

The injury to pecan nursery stock will be most serious on recently cleared land where decaying wood is abundant, as termites show a decided preference for such wood as a breeding place. New land to be planted to nurseries should have all dead wood removed from the soil, and the growing of two or three farm crops on the land is advisable before planting the seedling nuts for the ultimate propagation of budded and grafted trees. As a nursery practice, for the prevention of attack by this insect, it is urged strongly that recently cleared land be avoided. The same advice holds true in case a young pecan orchard is to be set out, as prevention is a far more reliable method of fighting the pest than is the use of any direct remedy.

FIG. 40.—The white ant (*Leucotermes flavipes*): Injury to roots of pecan nursery stock.

THE OAK OR HICKORY COSSID.[1]

The oak or hickory cossid in its larval state inhabits the trunks or larger branches of pecan, hickory, and oaks, in which it bores or tunnels in the hard wood, making galleries several inches in length. The work of the larva is detected rather readily by the castings of wood that are distributed at the base of the tree trunks. A careful search of the affected trees will reveal the hole from which these castings are pushed out by the larva, in order that its larval gallery may be kept clear. When the larva is full grown, it considerably enlarges this hole, which is more or less oval in shape, and then transforms to pupa. Just before the adult insect is ready to emerge, the pupa wriggles its way to the mouth of its gallery, and upon the issuance of the moth the pupal case is left protruding a little from the exit hole.

[1] *Cossula magnifica* Strecker.

DESCRIPTION.

The moth (fig. 41) generally is gray, mottled with brown and black blotches, and has an expanse of wings of about one and three-fourths inches. Each forewing has a large, light brown patch, sprinkled at the end with dark-brown streaks. The hind wings are darker gray than the forewings and are without any markings. The head is brown, the thorax light gray, peppered with faint dark spots, and the abdomen brownish gray.

FIG. 41.—The oak or hickory cossid (*Cossula magnifica*). Adult, or moth. Very slightly enlarged.

The full-grown larva (fig. 42) is about 1½ inches in length. The body is pinkish in general color and covered sparsely with short fine hairs which arise from the numerous tubercles. The head, cervical shield, or neck, and plates on the hind end of the body are shiny dark brown.

The pupa, to which the larva transforms upon attaining full growth, is generally brown, except the anterior part, which is blackish. On its head is a sharp projection which is of assistance to the pupa in pushing its way out of the larval burrow preparatory to the emergence of the adult moth.

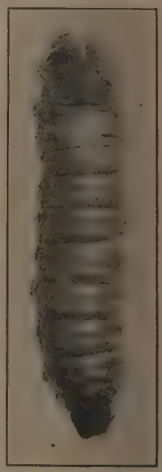

FIG. 42.—The oak or hickory cossid: Larva. Enlarged.

SEASONAL HISTORY AND HABITS.

The complete life cycle of this insect is not known, but it probably occupies only one year in the extreme South, and longer in its northern distribution. The moths emerge usually during May and June, and lay their eggs shortly after their appearance. The larvæ upon hatching first attack small twigs, in which they tunnel out the center or pithy wood. (Fig. 43.) When the larva has grown too large for the small twig upon which it has been feeding, it crawls out and enters a larger limb. By the early fall the larvæ will be found attacking the tree trunks or very large lower branches, in which they bore into the hard wood and make their galleries parallel with the grain. At this time and during the spring months the grower can detect piles of pellets of frass or castings at the base of the trees, and this is a very good way to locate the insect in pecan orchards. The transformation to pupa takes place within the larval gallery during April or May. By means of the sharp toothlike protuberance on

the head end the pupa wriggles along the tunnel to the exit hole, after which the skin splits open and the moth emerges.

CONTROL MEASURES.

All that can be done to control this insect in pecan orchards is to locate the larger limbs and tree trunks attacked, and destroy the larvæ by injecting small quantities of carbon disulphid into the holes, which should be stopped up immediately after treatment by means of putty, grafting wax, wooden pegs, or moist clay.

FIG. 43.—The oak or hickory cossid: Larval burrow in pecan twig. Enlarged.

THE FLAT-HEADED APPLE-TREE BORER.[1]

The flat-headed apple-tree borer has been known long as a more or less serious pest of certain fruit trees, such as the apple, quince, pear, peach, and apricot, and among its food plants are to be included several shade and forest trees. During the last few years this insect has been recognized in many sections of the pecan-growing belt as a serious enemy of pecan trees grown under orchard conditions, and in innumerable cases its larvæ have girdled and killed young trees. Its injuries are for the most part restricted to newly transplanted nursery trees and to trees that suffer from uncongenial soil or droughts, or are damaged by "barking" with cultivating implements. Pecan trees that have been affected by winter injury are very susceptible to the attacks of this borer. It is well known that pecan nursery stock does not stand transplanting so well as do many orchard fruit trees, as, for instance, the apple or peach, and perhaps this is because so much of the taproot is cut off in removing the trees from the nursery row. For the first year or two transplanted pecan nursery trees make little growth and do little more than establish themselves, even when the planting is done at what is considered the best time and with the utmost care. If the spring and summer following the setting out of the young trees are deficient in rainfall, the trees may be more or less seriously attacked by flat-headed borers, as the beetles seem to prefer to lay their eggs upon weakened or devitalized trees.

[1] *Chrysobothris femorata* Fab.

DESCRIPTION.

The beetle, as represented in figure 44, is oval and flattened and about one-half inch in length, but the size is somewhat variable. The antennæ, or "feelers," are short and toothlike, the eyes rather large, and each leg of the first pair is armed in front with a conspicuous tooth. The upper surface has a brownish metallic luster, the color of the underside is coppery bronze, and the part of the body underneath the wing covers is bright metallic greenish blue. The markings on the back, or wing covers, are well shown in the illustration.

FIG. 44.—The flat-headed apple-tree borer (*Chrysobothris femorata*): Parent beetle. Enlarged.

FIG. 45.—The flat-headed apple-tree borer: Larva in its burrow. Enlarged.

The larva (fig. 45) when full grown is about an inch long, without legs, and yellowish white. The second thoracic segment is much broadened and compressed, giving the larva the appearance of having a large flattened head. The larvæ within their galleries always assume a curved position, somewhat as is shown in the figure.

FIG. 46.—The flat-headed apple-tree borer: Pupa, ventral and dorsal views. Enlarged.

The pupa (fig. 46) is also yellowish white, somewhat more yellow than the larva, and it shows the undeveloped appendages and structures of the adult beetle.

SEASONAL HISTORY AND HABITS.

The beetles are to be found in pecan orchards from March to November, but they are especially abundant at two periods, namely, during May and from the middle of August until mid-

September. The beetles deposit their eggs in cracks or under bark scales upon the trunk or larger limbs. The young larva upon hatching gnaws through the bark and begins to feed upon the sapwood immediately beneath, making a more or less irregular gallery packed with sawdust castings, the gallery usually being evident through the bark. Some galleries have a very tortuous or spiral course (fig. 47), and because of this the affected trees are often girdled. If the trees are able to maintain considerable vitality in spite of the attacks, the larvæ do not enter the sapwood to transform to pupæ, as they do in dead and dying trees, but transformation to pupa takes place immediately under the bark, a slight excavation being made in the sapwood. One year is required for the complete development from egg to adult. Because of the different sizes of larvæ that may be found in trees at almost any season of the year, many growers believe that the insect has more than one brood. This, however, is to be explained by the great variation in rate of growth of the larvæ and the consequent variation in time of emergence of the beetles, this emergence taking place any time from March until early autumn.

FIG. 47.—The flat-headed apple-tree borer: Larval burrow in trunk of young pecan tree.

CONTROL MEASURES.

After borers have gained entrance to the trees nothing better can be done than to examine the trees carefully and remove the larvæ with a knife. The point of infestation on the trunk or limb usually can be detected by the discoloration and depression of the bark, which sometimes cracks open. In badly infested orchards the trees should be examined at least twice a year, and perhaps a third time would be advantageous. In cutting out "worms" great care should be taken not to

cause any unnecessary injury to the trees, and the places from which the borers have been removed should be painted with white lead or some good tree paint.

Certain washes have been used with some little success for protection against this insect in apple orchards, but it is believed that this means of fighting the borer on pecan is impracticable. Since the beetles are to be found in pecan orchards from March until November, several applications of the wash would be required and the cost for the treatment would be excessive.

In pecan orchards the use of trap logs made from newly cut branches of any favorite host plant, in order to attract the adult beetles for egg deposition, may be found practicable, for it is well known that this insect prefers dead or dying wood to living trees. Perhaps oak would be the best and most available wood to be had for these logs, but hickory or pecan would serve the same purpose, as the borer breeds abundantly in all of them. These trap logs, from 4 to 6 feet in length and from 3 to 4 inches in diameter, should be placed at intervals of 100 feet or less during the late winter or very early spring. After these logs have been left in the orchard for one season they should be burned the following winter. The writer has captured hundreds of beetles on pecan and oak logs that were smeared with a viscous substance and placed in pecan orchards. This plan has not been tested on a large scale, but it promises to be of value, especially in badly infested orchards that have been neglected for some time and are adjacent to extensive woodlands.

Careful cultural methods are urged strongly as a measure of protection. All dead and dying trees and all pruned limbs or branches should be removed promptly and burned, for such wood affords an ideal breeding place for the borer and is therefore a menace to the orchard. The keeping of pecan wood about the orchard for future use as fuel or for other purposes is a bad orchard practice and can not be condemned too strongly. In several instances the writer has found large numbers of flat-headed borers in limbs and branches of pecan stored for firewood. In the transplanting of nursery stock to the orchard, every care should be taken to have the trees set out under the best conditions; and, judging from observations, early planting, say, in December and January, and not later than February, is to be recommended, so that the trees will get the benefit of the winter rains. As a measure of protection it is also essential that young trees be kept in a vigorous growing condition by frequent cultivation and the planting of tree rows to some suitable leguminous crop. The use of fertilizers also will help the trees to withstand attack by this species as well as by other wood-boring insects. It is important to remember that thrifty trees are less liable to attack than sickly or stunted ones and injury is best avoided by the maintenance of trees in a vigorous condition of growth.

THE RED-SHOULDERED SHOT-HOLE BORER.[1]

The red-shouldered shot-hole borer infests dead or dying pecan limbs, into which it bores for a considerable depth. The borings or frass of the larvæ are very fine and sawdust-like in appearance, and are firmly packed or compressed within the galleries, which run with the grain of the wood. Upon attaining full growth the larvæ pupate some time during the fall or spring, and the beetles emerge during the spring months. Beetles are sometimes found during the early winter in the larval galleries, in which they remain until warm weather begins. The beetles invariably make their way out at right angles to the larval galleries, and emerge through circular holes in the bark, as is shown in figure 48.

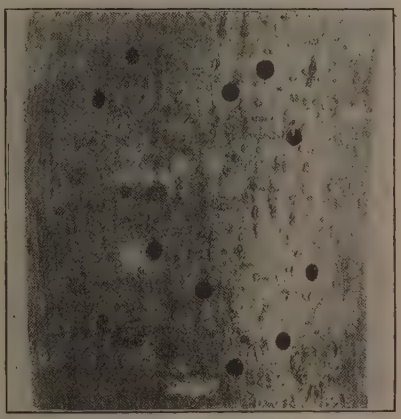

FIG. 48.—The red-shouldered shot-hole borer (*[Sinoxylon] Xylobiops basilaris*): Exit holes of adult beetles in pecan limb.

According to Mr. C. A. Reed, Nut Culturist in the Bureau of Plant Industry, trees so severely cut back for topworking or other purposes that the trunk becomes saturated with sap and the sap cells ruptured are fairly certain to become infested with shot-hole borers. It has been observed by some that not infrequently the borers are charged with being responsible for the unhealthy and apparently diseased condition of the tree, whereas actually the diseased condition of the trunk is responsible for the presence of the insects.

The beetle is black and has small punctures over the greater part of its body. The wing covers at the base or shoulder are reddish and at the tip or posterior end they are obliquely cut off, the edge of the cut being armed with three conspicuous teeth.

CONTROL MEASURES.

Since the insect attacks, as a rule, only dead or dying pecan wood, it is not to be considered a serious pest. Occasionally it attacks rather healthy trees, but it never causes any serious damage to them, since the larvæ can not subsist on wood containing a good flow of sap. As a protection against this insect, as well as against the more injurious wood-boring species, all dead trees and prunings should be removed from the orchard promptly and burned. Moreover, the trees should be kept in vigorous growing condition by practicing good orchard management.

[1] (*Sinoxylon*) *Xylobiops basilaris* Say.

THE BELTED CHION.[1]

The belted chion, in its larval state, attacks the pecan and hickories as well as other trees, forming long galleries in the trunk or limbs of weakened or dead trees. The galleries (fig. 49) are excavated to a considerable depth in the heartwood, in which they run in the same direction as the grain. The larva is a yellowish white, round-headed borer, with brown head and black jaws. Upon attaining its full development it changes to a pupa within its gallery and the adult beetle in emerging cuts a large circular exit hole through the bark (fig. 50). The beetles make their appearance any time from March to September, as has been determined from rearing records.

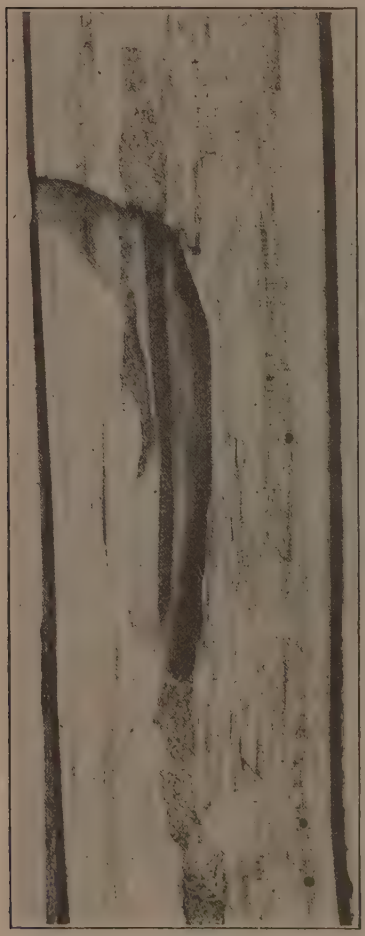

FIG. 49.—The belted chion (*Chion cinctus*): Larval galleries on pecan limb.

The size of the beetles varies, the length being from two-thirds to a little more than an inch, and in the males the antennæ, or feelers, are more than twice the length of the body. The color is light brown, usually with a short, oblique, dull band near the base of each wing cover, but in some specimens the bands are absent. Each wing cover bears two slender, conspicuous spines at its tip, and on each side of the thorax is a short, prominent spine. (See figs. 51 and 52.)

CONTROL MEASURES.

About all that is necessary to prevent injury to the pecan orchard from this pest is to remove dying trees or dead wood promptly and destroy the same by burning, as it is well known that this species prefers to breed in such material.

THE HICKORY TWIG-GIRDLER.[2]

The hickory twig-girdler is more or less familiar to all pecan growers and is an insect that is frequently the subject of inquiry. This spe-

[1] *Chion cinctus* Drury.

[2] *Oncideres cingulatus* Say.

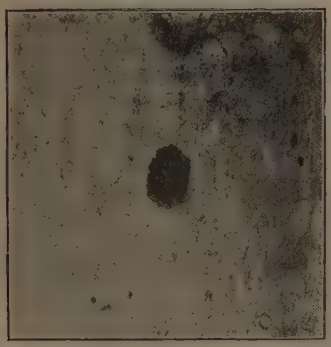

FIG. 50.—The belted chion: Exit hole of beetle.

FIG. 51.—The belted chion: Adult female beetle. Enlarged.

FIG. 52.—The belted chion: Adult male beetle. Enlarged.

cies is accountable for the wholesale cutting off or pruning of pecan twigs, this injury being often conspicuous during the late summer and early fall. This beetle is found over a wide range of territory, occurring in most of the Eastern, Central, and Southern States, but in its more northern distribution the extent of its depredations is not very great. In the pecan-growing sections of the South it ranks as a first-class pest because of the excessive severing of branches from pecan orchard and nursery trees by the adult beetles. Besides attacking the pecan, this species has been reported as damaging the hickory, persimmon, oak, walnut, elm, maple, locust, linden, and various pome and stone fruits, including the apple, pear, quince, cherry, peach, and plum, as well as orange trees and rosebushes. In the South, however, it seems to confine its attacks, for the most part, to the pecan, hickory, and persimmon.

FIG. 53.—The hickory twig-girdler (*Oncideres cingulatus*): Bunches of cut-off twigs caught in branches of hickory tree.

When the beetles occur in abundance they are capable of doing much damage by severing branches for the purpose of egg-laying. It is not uncommon to see the ground under pecan or hickory trees literally covered with twigs that have been cut off by the beetles, and twigs often accumulate in the tree tops in conspicuous bunches (fig. 53). By the severance of the tips of the branches the fruiting area of the tree is greatly lessened or reduced and the nut crop indirectly affected for the following year, and perhaps for a longer period. This type of injury, besides affecting the nut production, causes the development of many offshoots, which destroy to some extent the symmetry of the tree. Pecan nurseries growing adjacent to a badly infested territory often suffer great loss from the girdling of the terminal branches of the nursery trees.

DESCRIPTION, SEASONAL HISTORY, AND HABITS.

The beetles (fig. 54; fig. 55, *a*) range in length from one-half to five-eighths of an inch, the female being larger and more robust than

the male. They have long antennæ or feelers; those of the males are considerably longer than the body, but those of the female are only a trifle longer than the body. The body is subcylindrical, and the general color is grayish brown, there being a rather broad ashy band or belt extending over the middle of the wing covers. The thorax is about the same color as the ashy band, but the head is more or less reddish. Upon close inspection it will be observed that the wing covers are ornamented with many yellowish or straw-colored spots.

FIG. 54.—The hickory twig-girdler. Adult, or beetle. Enlarged.

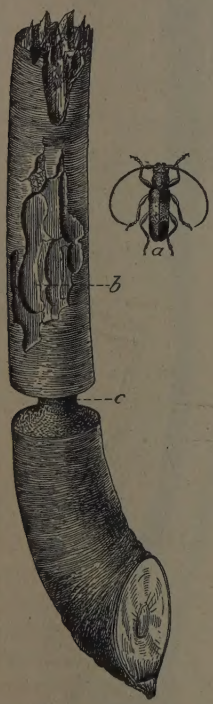

FIG. 55.—The hickory twig-girdler: *a*, Beetle; *b*, larval mines in bark and outer wood; *c*, girdling work of adult. (Webb.)

The eggs, which are always deposited in the severed branches, are white, elongate oval in shape, and about one-tenth of an inch in length.

The beetles, which begin to make their appearance in pecan orchards by the last of August or early in September, have very interesting habits. It is only the female of the species that cuts off the twigs, but both sexes feed more or less upon the tender bark and wood of the tips of the branches. The branches apparently are severed by the female in order that congenial conditions may be provided for the development of the larvæ, which are unable to subsist on wood containing sap, as has been determined definitely by field observations. It has been observed that the female in girdling does not make a complete circle at once, but cuts section by section until the entire twig has been girdled. The girdling extends through the bark and well into the wood, leaving only a narrow portion of the heartwood untouched. (See fig. 55, *c*.) Usually the weight of the branch, with the assistance of the wind, causes it to bend down or break off.

The eggs are laid during or after the cutting process, but never before the beetle has cut at least one section. They are inserted singly beneath the bark, or slightly into the wood, near a

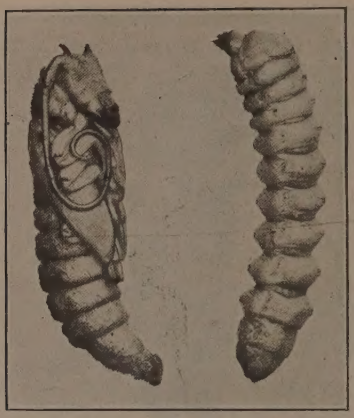

FIG. 56.—The hickory twig-girdler: Pupa at left, larva at right. Enlarged.

are to be found occasionally in offshoots. After the insertion of the eggs in the twig the puncture is sealed with a shiny, gummy substance, and the beetle then scars the twig for a short distance below the egg puncture. The number of eggs per twig may range from 3 to 40, although occasionally a severed branch without any eggs is found. The egg stage lasts about three weeks.

The larvæ (fig. 56, at right), which are whitish, legless grubs, make little growth during the fall or winter months, but with the advent of warm weather in the spring they grow very rapidly. In making their tunnels in the twig (fig. 55, *b*; fig. 57) they work usually toward the severed end and feed only on the woody fibers, leaving the bark intact. During the late spring or early summer most of the larvæ[1] make a few circular holes in the bark, from which they cast out pellets of frass and excrement. Just prior to transformation to pupa (fig. 56, at left) each larva closes the end of its gallery with shredded shavings, making the pupation quarters, from which the adult emerges by gnawing a more or less circular hole in the bark.

bud scar or adjacent to an offshoot. Usually they are deposited in the main stem of the branch, but if the branch is of a good size some eggs

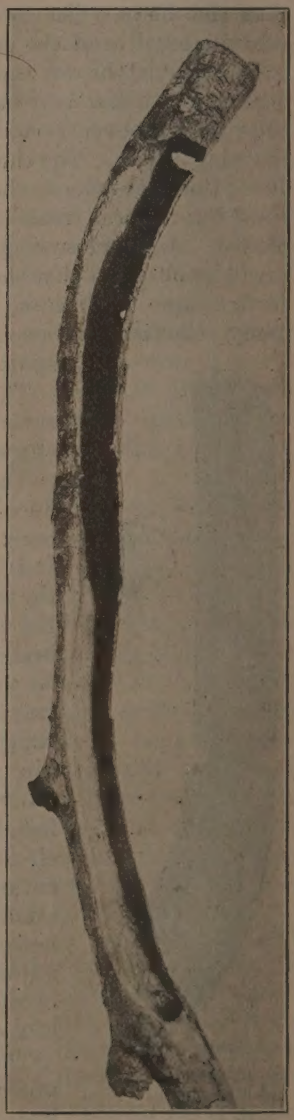

FIG. 57.—The hickory twig-girdler: Larval burrow in cut-off pecan twig.

[1] A few larvæ may not transform until the second season.

As stated before, the beetles begin to make their appearance in the pecan orchards about the last of August, and they may be found continuing their girdling operation until cold weather.

CONTROL MEASURES.

For the control of this pest all that is necessary is to gather the severed branches and burn them in the fall or winter. Care should be exercised to collect all branches from the ground, as well as those that may be lodged in the trees. By following this procedure all the eggs and larvæ which would otherwise develop into beetles the following summer will be destroyed, and thus the source of infestation will be eliminated. Pecan orchards that are growing adjacent to native hickory or persimmon trees will be found to be worst infested, because, as has been stated, this insect breeds abundantly in the severed branches of such trees. Under such conditions it would pay, perhaps, to destroy the branches cut from the hickory and persimmon trees immediately adjacent to commercial plantings of pecans.

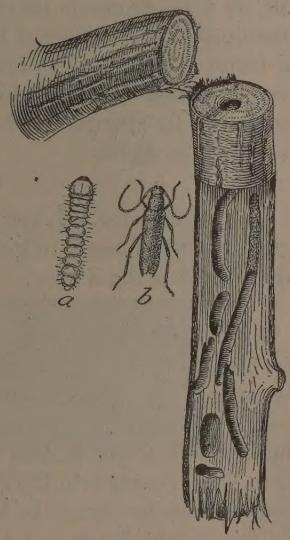

FIG. 58.—The oak pruner (*Elaphidion villosum*): *a*, Larva; *b*, adult; pruned twig and larval mines at right.

THE OAK PRUNER.[1]

During the fall and winter twigs or branches pruned by the larvæ or grubs of the dark-brown beetle known as the oak pruner (fig. 58) are to be found under pecan trees, as well as under oak, hickory, and various other forest, shade, and fruit trees. This insect does not especially favor the pecan, but seems to show a preference for various oaks. Although this insect occurs from New England westward to Michigan and southward to the Gulf States, it is seen too rarely in sufficient numbers in its extreme southern distribution to be ranked as a serious pest. In the North, however, serious injuries are sometimes caused by its pernicious pruning habits.

In the case of the pecan twig-girdler the twigs are cut off by the female beetle, but with the oak pruner the larvæ amputate the branches by gnawing a circular groove in the wood, leaving only the bark intact. The branches so amputated are usually brought to the ground by the first strong wind, or, in some instances no doubt, by the weight of the branch itself. The end of the severed branch presents a *smoothly cut* surface (see fig. 58), near the center of

[1] *Elaphidion villosum* Fab.

which will be seen a more or less oval opening plugged with fine shavings and sawdust. By way of contrast it may be stated that the end of the twig that is cut off by the pecan twig-girdler always presents at its center a more or less jagged surface.

In brief, the seasonal history is as follows: The beetles (see fig. 58, *b*) usually appear during the spring or early part of the summer, and the eggs are deposited in the leaf axils of the smaller twigs of living trees. Upon hatching, the larva feeds upon the wood immediately under the bark, but later it bores into the heartwood, where it makes an oval gallery several inches in length. (See fig. 58, at right.) In the fall it cuts away the wood at the end of its gallery in such a manner that the wind causes the twig to snap off. The larva (fig. 58, *a*) then proceeds to stop up the end of its channel with coarse shavings. In the larval burrow within the fallen branch the pupa is formed, either in the fall or early spring, and during the spring or early summer the beetle makes its appearance in the pecan orchards. Occasionally specimens of adults can be found in the pecan orchards as early as April.

CONTROL MEASURES.

The remedy for this species is the same as that for the pecan twig-girdler and consists in gathering the severed branches and burning them during the winter.

SCALE INSECTS.

Fortunately for the pecan grower it is seldom, if ever, necessary for him to spray his orchard trees for the control of scale insects, as is the common practice in the growing of apples, peaches, and other fruits. The pecan is not immune to attack by insects of this group, but because of the limited infestation scale insects have not up to this time (1917) come into the category of pests of first importance. When scale insects are found to be present on pecan trees specimens should be sent to the Bureau of Entomology for observation or to the State agricultural experiment station.